« Learnance » a relevant Tool to study Relationships to Scientific Knowledge and Effects of School Science Categorization

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Abstract: The purpose of this paper is to present complementary studies focused on the *a posteriori* effects of school science categorization (SSC) on adults' relationships to scientific knowledge. This interest of this issue is linked to the fact that specificities of the science secondary school diplomas in many countries such as France make many adults feel later unable to explore any issues related to school science and to STEM. In terms of methods, this paper presents how Carré's "learnance" concept (2005) can be used in this purpose as a relevant tool. As results, those studies shows that the effects of this SSC can be described by considering a general "learnance" attitude and a" spectrum of" thematic "learnance", according to two complementary empirical approaches: the implementation of evidence of a thematic deficit of *a posteriori* learnance; the study of "positive deviants"; and who, despite their initial academic categorization, appropriate scientific knowledge, like some chronic patients or amateur scientists.

Keywords: STEM, scientific knowledge, academic categorization, obstacles, learnance scale

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1. Categorization of pupils and students as scientists or not

1.1. School scientific categorization (SSC) and the resulting obstacles

In several countries such as France, secondary education is partly based on a categorization of young people into scientists or not. This school science categorization (SSC) has consequences in terms of skills, power to act or problem solving. This article focuses on the methods and tools for exploring them for an adult, in particular in terms of thematic variation of their learnance, in the sense in which this term has been introduced by Carré (2005), as a new way of describing a "relationship to knowledge".

With the ambivalent role played by the "*Baccalauréat* S" stream, French secondary education (or similar educative systems in equivalent countries) combines the functions of training in algebraic sciences and the management of a stream of excellence. In France, each year, only 25% of each age group is thus entitled to be declared "scientific" at the baccalaureate level (RERS, 2014). In other words, the education system judges and declares the majority of each age group as not competent in "Science" (STEM), especially since many pupils are excluded from the S stream by insufficient scores in Math. Thus, for a large proportion of those not received at Bac S, cognitive obstacles (Bachelard, 1938) are doubled by two others, linked to this incompetence sanction that we can call "motivational (conative)" and "scholastic" (Las Vergnas, 2012;2013).

The "motivational" or "conative obstacle" expresses the fact that individuals feel unable to deal with a scientific issue because of the sanction of incapacity received during their previous school experience. With reference to the "self-efficacy" feeling (SEF) introduced by Bandura (1997), it can be hypothesized that this motivational obstacle is similar to a "self-inefficacy feeling" (SIEF) with regard to what has been learned to be called "science" in middle or high school.

The "scholastic obstacle" makes it possible to describe the fact that the "relationship to science" of an action carried out by the person is hidden from this person, scotomized; this obstacle appears in adults for whom the qualification of "scientist" can only be attributed to what reminds them of school scientific disciplines. It prevents the individual from seeing that some of the positive results he or she achieves are related to what can be described as "scientific" abilities.

1.2. SSC as a « total social fact »

From a sociological point of view, the SSC is undoubtedly a total social fact, mechanically linked to the distribution of secondary school diploma results, reinforced by the low volume of the too rare hybrid courses and the role of the Bac S as a field of excellence. This SSC generates several other effects that can be observed at the societal level: some are direct consequences, such as in France the systematic difficulties of the majority of non-Baccalaureate S students to consider using even rudimentary algebraic formalism; others are secondary consequences, such as the futile repetition of discourse on an alleged disaffection with science and the need to compensate it with policies of "scientific and technological culture[which must be brought to the level of] a national priority" (Blandin and Renar 2003) or "an imperative" (Olivier and Leleux, 2014) from which the institutionalization of this field of practice results (Las Vergnas, 2012).

1.3. Emotional obstacles have been well identified

In the English-speaking world, many authors use a scale of "anxiety in mathematics" (Suinn and Winston, 2003) and have shown that those who achieve a high level of anxiety « *underperform in math relative to their low-math-anxious counterparts and tend to avoid math and math-related situations, which in turn can bias them away from taking math classes or even entire math-related career paths* ». (Lyons and Beilock, 2012); Several French authors have also shown the existence of emotional obstacles (Nimier, 1988; Baruk, 1973) in therapeutic orientated works.

Klinger (2006) indicates that, although there has been little work on adult attitudes towards math, « *Fear of failure induced by the nature of some mathematics teaching and assessment practices* [has been noticed by Singh (1993)] *as a cause of anxiety in adults ».* Klinger completes this observation with his own synthesis of the effects of the school experience:

> *"Mathematical self-concepts can be strongly influenced by primary school experiences and the attitudes of parents, with traumatic early mathematics learning experiences being capable of exerting a long term effect (Relich, 1996) so that many people cast themselves as 'non-math' types at an early age (Mitchell & Gilson, 1997), leading to a lack of motivation." […] Negative views of mathematics clearly prevail during school years and, in the absence of contrary evidence, there can be little doubt that children carry their views into adulthood and into the broader population. (p.165-166)*

The existence of a conative obstacle is therefore proven and in the same publication, Klinger goes on to state that his own work confirms that negative attitudes, lack of SEF and mathematical anxiety in adults are « *strongly influenced by early learning experiences* ».

On the other hand, the link that this obstacle has with the total and unavoidable nature of the SSC has not really been highlighted. However, it can be hypothesized that the correlation between adult SEF in mathematics and previous school experience is greatly amplified by the representation of a boundary that would make one lifetime on one side or the other, reflecting Epinal's image of what is called in France the "math hump".

2. « Learnance » concept as an analyzer of the individual effects of SSC

Several ongoing studies are based on the comparison of adults who may have developed diverse "relationships to science": those studies look for correlations between variables that could potentially explain these relationship differences. Their starting point is that "learnance" (in French "apprenance"), defined as "a set of dispositions [...] favorable to the act of learning" (Carré, 2005) can, while remaining sustainable from one day to the next, prove to be more or less developed in the same person according to major themes, as soon as the definition "to the act of learning... in a given field" is completed. This learning could thus be systematically higher for what the person has permanently identified as a focus of interest

and/or MS than for other areas that would seem boring or painful to him or her.

These works carried out by the author and some of his doctoral students thus aims to objectify the thematic "learnance gaps" that would result from a "SEF hole" linked to the memory of the school sanction, which would in a way have "burned" it. They are based on a psychometric learnance measurement scale that has been defined and tested in particular by Jore (2012) that we thematize in order to measure specific learnance and to distinguish a measure of learnance "in general" from a measure of learnance "for science-related subjects".

3. Two symmetrical pathways

In concrete terms, two symmetrical empirical approaches are used, the first proposing to describe the contours of the conative obstacle as best as possible, while the second seeks to highlight ways of counterbalancing it, i.e. to see how certain motivations can make some adults who are not academically scientific reveal themselves to be specifically involved in reflexive activities that can be described as "scientific".

3.1. The identification of a thematic learnance deficit

The hypothesis is simple: the victims of the conative obstacle have a weaker learnance in "scientific" or techno-scientific subjects than their learnance in general, hence the idea of talking about a "learnance spectrum" with which we can scan the different themes and compare them with the learnance "in general": we are thus looking for holes in the spectrum of interests: blind spots, areas where curiosity would have been "burned", disgusted in a sustainable way.

This question is being explored from three complementary angles: the resumption of studies by adults in Cameroon, by Temkeng (PhD in progress), the allergy to algebraic formulation by Kubryk (PhD in Progress) and finally the localized nature of computational skills for young people in the future youth scheme by Ben Nejma, (PhD in Progress). As those work are still in progress, it is premature to present results here, but it can nevertheless be said that they confirm the use of thematic scales: thus, the first factor appearing in correspondences analyses of the Temkeng questionnaires indicate that the scientific learnance of adults returning to studies in Cameroon is strongly correlated with their school past and not with their learnance in general.

3.2. The search for positive deviance from the norm of SSC

This idea is symmetrical to that of studying deficits in the spectrum of interest or learnance. Rather than observing the modalities and characteristics of the alleged lack of interest in SSC, it is a matter of looking for people who would develop, despite SSC, qualifying activities as scientists and studying their characteristics. This method is a transposition of the "positive deviance from the norm" approach applied in social or health interventions by Singhal (2010).

Again, the starting point is simple: a set of motivations might for some people cancel the

obstacles resulting from SSC; studying them would help to describe what these obstacles really are by seeing what can cancel them out. To analyze these engagement profiles, the "positive deviants" (PD) model makes it possible to identify and then describe such "non-scientists" in the academic sense, who, despite SSC, invest in situations where they will appropriate scientific knowledge and solve it with problems qualified (at least academically) as scientists.

General and thematic learnances are also to be invoked in these studies as potentially explanatory variables, as well as those describing the environment and socio-cultural characteristics. In general, the output variables are those that allow the analysis of the action and possibly the effectiveness of learning or problem solving. If the positive deviance has become sufficiently established over time to have caused thematic learnance to evolve somewhat, they can also be output variables, studied longitudinally over time. In these cases, the learnance spectrum (and its possible holes) can be both a partial predictor and a consequence of such positive deviations.

Two studies will thus be set up by the author according to the same protocol, one for amateur astronomers and the other for patients involved in associations.

3.3. Relationships to one's health, a favourable field

In the meantime, provisional indications can be drawn from the observation of the PD landscape, considering a typology of scientific engagement at four levels: (DP1) occasional curious; (DP2) perennial self-learners, active members of clubs or networks; (DP3) practitioners associated as lay collaborators in Pro-Ams research, but not in protocol or conclusions; (DP4) cooperators, recognized as co-researchers by academic interlocutors.

These DP4s are few in number. We meet them in three circumstances:

(1) Practice of sciences traditionally "including amateurs" (astronomy, entomology...),

(2) Involvement of chronic patients in an exchange network contributing to a collective self-care clinic,

(3) Involvement of activists in popular epidemiological research (Brown, 1987), in relation to a problem of pollution, food risk or the protection of biodiversity.

However, even if they are "amateurs", many science-leisure practitioners are in fact found not to have been classified as "non-scientific" in secondary school. It is therefore more in the categories of patients (2) and popular epidemiology activists (3) that we find "real" DP4s, for whom reflexivity is fed simultaneously by the experiential experiences and knowledge of lay people and the clinical or academic knowledge of scientists (Jouet et al, 2014). Thus these "true" DP4s would be observed especially when an intrinsic motivation is of sufficient intensity to counterbalance the conative obstacle, which refers to the idea of a vital need for knowledge.

In concrete terms, the scope of one's own health (whether good or degraded by a chronic disease) is therefore a relevant place to observe the effects of SSC. In the representations of patients and relatives, the problems raised and to be solved are certainly linked to the scientific register, without being too formally arid. The intrinsic motivations to get better (or not to get worse) may be strong enough to counteract the conative obstacle.

But for all that, the intrinsic motivation is far from sufficient to make everyone a DP4. Vicherat (PhD in progress) is precisely studying the specificities of people who in the middle of their lives take care of their good health: is it because they are simply more "learning" than others? Research is still ongoing, but it can be hypothesized that for a motivation to overcome the conative obstacle, knowledge appropriation must produce results, because then the attitude of positive deviance can relieve and produce SEF. However, this must also be in accordance with the representations of what can be useful to do or learn: if we think that our maintenance in good health depends above all on the fate or possibilities of curative medicine, there is little point in learning to take care of it on a daily basis. Renet's current study (PhD in progress) on knowledge exchanges between chronic lung patients and pharmacists thus looks at whether learnance in general and learnance for health issues are correlated with each other and how one or the other may affect these exchanges.

4. Learnance and other "relationships to specific knowledge".

Learnances and their associated scales are thus relevant instruments for studying the effects of SSC on adults, since we also consider a spectrum of thematic learning. By using them with the other descriptive variables of people and the environment, we have a battery of variables that can potentially explain learning activities, or even their effectiveness.

These analyses can be put in perspective with the work on "relationship to writing" and more generally, the approaches mentioned here can be transposed to other thematic fields - as soon as these fields generate shared conative obstacles, in connection with a socio-cultural issue - such as foreign languages, joining for example the work on language anxiety (Brewer, 2010). They are therefore a fertile field for many researchers in education and training.

Therefore, stabilizing such a model of a thematic learnances spectrum should be a priority objective. This implies finding the best tools to handle this spectrum and work in a differential way on learnance. At the heart of this issue is the way we see the stability we want to give to the concept of learnance. As a "disposition" it must be stable, transversal, but it must be allowed to work on its two partial derivatives, temporal and thematic. Indeed, in the triadic socio-cognitive framework (Bandura, 2003), what interests us when studying these "relationships to" is to be able to describe the links between (1) dispositions to learn, (2) environment/context and (3) behaviors/actions. We therefore need two instruments to measure/observe "relationships to knowledge": on the one hand, a measurable "magnitude" characteristic of the arrangement that would be predictive of behaviors or actions (learning or problem solving) depending on the environments, namely "learnance in general"; on the other hand, we need something to qualify knowledge acquisition actions, which is what we usually call "learning behavior" or "learning episode".

If we attempt an analogy with the question of "relationships to food", what we want to describe is the interaction between appetite (a relatively durable disposition), hunger (which depends on the context) and eating behavior. What we are trying to formulate is the question of how appetite is a function of eating and how it relates to hunger. In the case of DP4 positive deviants, we want to show that for them the appetite is returning while eating. More precisely, their learnance for science is reborn as they develop learning actions. And to study and describe it, we need to refine our instruments in terms of differential learnance analysis tools. This is the key to many future work on "relationships to science", but also more generally on all “relationships to any specific knowledge field”.

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